# Enhancing the Sustainability and Resilience of Cairo's Informal Settlements FROM THE GROUND UP



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## FROM THE GROUND UP

Enhancing the Sustainability and Resilience of Cairo's Informal Settlements



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> This thesis is dedicated to Anne Langridge 1952-2019

## George Langridge Gould

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The world is becoming increasingly urban, and the phenomenon of migration from rural areas to cities is particularly prominent in the developing world. This movement is exacerbating the negative impacts of cities on the natural environment, with dire consequences.

By focussing on informal settlements in the city of Cairo - the largest city in Africa - this thesis aims to explore ways of making the resource-deprived communities of this city more environmentally sustainable, without sacrificing their social qualities, and expanding the economic opportunities that are available.

A combination of methods and tools are used for this purpose, ranging from green space analysis, non-prescriptive and adaptable uses and building designs, elements of the green economy, and community-led implementation.

The outcome of this thesis, therefore, is a design model that offers sufficient flexibility that it can be applied to any new settlement in Cairo, but is also sensitive towards the local culture.



## Abstract

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The first chapter provides a look at both existing literature and examples of slum upgrading around the world, with a particular focus on the factors that make such projects successful.

The second chapter zooms in to the Egyptian context, justifying the selection of Cairo as a case study, and examining the nature of informal settlements in the city.

The third chapter examines the methodologies and tools that will be utilised in the design process. This encompasses both the design methods, and the green space analysis framework.

The fourth chapter presents the result of the design phase of the thesis: a model for green architecture in Cairo's informal settlements.

Lastly, the fifth chapter provides some further details about how this design and this project can be implemented and made viable: for example, the challenges of economic limitations and provision of water.

This thesis tackles an impossible challenge, and it should not be expected that a single answer can be found. It is to be hoped, however, that this thesis can provide some solutions to an issue that exists globally.



# **Reading Guide**



## I. Introduction

Urban design is a difficult industry to define. It overlaps with many other disciplines and professions, such that it cannot truly be pinned down to one single characteristic or activity. However, as it is useful to have an understanding of the context of this thesis, a simple working definition may be devised.

In essence, urban design is the activity of making cities better. Critically, this definition does not specify that cities must be better only for people; all users are considered, human or not.

Additionally, urban design places a particular emphasis on the physical environment - the buildings, and the spaces between and around the buildings. This statement can be further expanded to say that urban design is about how people (and other urban entities) interact with the physical environment.

Consequently, it is fair to define urban design in this thesis as the relationships of users and environment, and the task of addressing issues that negatively impact those relationships.

## What What issue is being addressed in this thesis?

Urbanisation over the last century has been one nities often enjoy a higher quality of life, with of the most dramatic social movements in recent history. Between 1960 and 2017, the share of the world's population that lived in urban settings increased from 33% (1.01 billion people) to nearly 55% (4.11 billion people) (Ritchie & Roser, 2020). UN estimates suggest that the world's urban population will continue to grow sharply. A 2003 study, the Global Report on Human Settlements estimated that an additional 2 billion people would move into urban centres by 2030 (UN-Habitat, 2003).

The rapid urbanisation of these regions has had a transformative effect on the societies in which they are occurring, with both positive and negative impacts. On the one hand, urban commuincreased access to goods and services, education, employment and amenities. However, the growth of urban agglomerations can also erode social networks, force people into slums or informal settlements, and create additional demands on the ecology and natural environment within the city, as well as beyond its boundaries.

The urbanisation of the world's population, therefore, poses both challenges and opportunities. The environmental impacts of cities, however, makes it an issue to be addressed.

## Where Where is the issue most relevant or urgent?

The urbanisation phenomenon is not equal These cities deserve to be prioritised as they not around the world; either in quantity or in charonly home to people in need, but they are seeing acter. Countries classified by the United Nations a greater increase in their numbers, and they are as "developing economies" are experiencing the more vulnerable than urban residents in the dehighest rates of urbanisation. This is most noticeveloped world. able in Africa and Asia, where, between 1960 and 2017, the share of the population that is urban Although this thesis uses Cairo, Egypt, as a case study, it is with an eye towards a global issue has grown from 18% to 42% and 21% to 49% respectively (Ritchie & Roser, 2020). that this thesis is written.

Urbanisation in these parts of the world is characterised by a lack of economic opportunities, public sector oversight, and institutional capacity. Megacities - that is, settlements of 10 million or more inhabitants - have grown in the developing world, with large concentrations of urban poor, living in unsatisfactory conditions.





Opposite: map of world showing existing and forecast megacities (UN, 2018)

Below: map of world showing countries according to 2019 development status (UN, 2018)

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# **Why** Why is this issue important?

The question can be asked: what exactly are the impacts of cities on the natural environment? The table below divides the impacts into two categories: direct and indirect impacts. Direct impacts include the externalities of urban life, such as the emissions of vehicles and industries, and the climatic effects of urban materials (eg. glass, concrete, metal, brick). The indirect impacts are

those that originate from the need to deliver goods and services to urban inhabitants.

It is also important to note the consequences that these impacts can have (shown to the right of the table). All of these consequences pose serious challenges to the world's existing systems.



## **How** How will the issue be addressed?

How best can the environmental impacts of urbanisation in the developing world be tackled? There is, of course, no single approach that can resolve such a complicated issue. One approach that is promising, however, is to apply the principles of biophilic urban design.

Tim Beatley describes a biophilic city as "a biodiverse city, a city full of nature, a place where in the normal course of work and play and life residents feel, see, and experience rich nature - plants, trees, animals" (Beatley, 2011, p. 45). In other words, a biophilic city may be one in which the saturation in natural elements makes it a consistent element of life for all residents.

There are numerous advantages offered by this philosophy. Access and experience of nature, for example, have a proven effect on reducing stress and improving health (Egerer *et al.*, 2019). Plants are also natural filters, reducing the concentration of pollutants in air, water and soil (Bargagli *et al.*, 2019).

The diagram on the following pages shows the 'affordances' of green space in cities: that is, what services, benefits and opportunities they afford. These affordances are divided into enviro-centric - mainly benefiting the natural environment - and anthro-centric (mainly benefiting human users and residents.

A central aspect of the biophilic philosophy, however, is that human systems and natural systems are not distinct or separate from each other. Hence the enviro-centric affordances also benefit people. (Note: this is not necessarily true in reverse for anthro-centric affordances)

Problems emerge where nature is removed from the daily experience of urban residents, as can be seen in many urbanising cities. The solution, therefore, is to bring nature back.

#### BUILDING

green rooftops & rooftop gardens, sky gardens and green atria, green wals,

#### BLOCK

green courtyards, clustered housing around green areas, natives species yards & spaces

#### STREET

green streets, sidewalk gardens, urban trees, low-impact development, vegetated swales and skinny streets, edible landscaping, high degree of permeability

#### NEIGHBOURHOOD

stream daylighting & stream restoration, urban forests, ecology parks, community gardens, neighbourhood parks and pocket parks, greening greyfields and brownfields

#### COMMUNITY

urban creeks and riparian areas, urban ecological networks, city tree canopy, community forest & community orchards, greening utility corridors

#### REGION

river systems & floodplains, riparian systems, regional green space systems, greening major transport corridors

> Above: elements of biophilic urban design across scales (modified from Beatley, 2011, p. 84)

Opposite: impacts of urban settlements on the natural environment.

# **Green Space Affordances**

## Enviro-centric affordances

## **Green Space Affordances** Anthro-centric affordances





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# **Thesis Outline**

## **Background & Theory**

This chapter will draw on existing literature in order to explore the themes of urban renewal and regeneration in informal settlements, slums, and deprived areas.

#### Analysis & Context

In this chapter, the context of informal settlements in Egypt and Cairo will be examined in detail. The discussion will focus primarily on the characteristics of informal settlements (both good and bad) and their patterns of growth and change.

#### Methodology

This section will present the key design principals and concepts that have been applied in this thesis. This includes both the framework for urban green space analysis/design, as well as identification of key aspects of design for informality.

#### **Presentation of Design Proposals**

In this part of the thesis, the design solution for Cairo's informal settlements will be presented. Given that this is not a site-specific urban design project, an element of abstraction should be anticipated.

## **Testing the Design**

The final chapter will seek to demonstrate how the design solution will work, and provide details of its implementation and viability. After this chapter, some concluding remarks and reflections upon the process will be included.

The background and theory helps to inform the methodology

This feeds into this

# Who

## Who are the main actors and stakeholders that can address this issue?

Urban design projects inevitably involve many stakeholder groups, and in order to ensure the success of the project, it is necessary to consider all the potential contributors, beneficiaries and interested parties.

For this thesis, stakeholders are divided into two groups: top-down and bottom-up. Top-down stakeholders include organisations that are experienced or capable of enacting change for the benefit of others; it includes government agencies, international aid and development organisations, and business and corporate bodies.

These groups are labelled as top-down because they approach the issue from a large-scale perspective, looking at the big picture. This gives



Top-down Egyptian government Local and municipal gov't NGOs Intergovernmental organisations (eg. UN, IMF, World Bank)

## Bottom-up

Agricultural land owners Building owners & developers Residents, businesses & workers Local community leaders Neighbouring stakeholders

> Above: the principal stakeholders considered in this thesis.

Left: the six principal UN Sustainable Development Goals (SDGs) relevant to this thesis.

them the ability to manage connections, but often at the cost of nuance and flexibility.

The bottom-up group applies to those who are directly involved in the project, such as land-owners, residents, and local community figures. The input of these stakeholders is important because they are the best informed about the conditions of life in the area, and are therefore capable of adding insight into the specific challenges and obstacles. This insight, however, can come at the expense of consideration of the larger implications of the project.

Note: neglect and lack of interest by the Egyptian government is one of the key characteristics of informal settlements in Cairo.

Contextually responsive urban design is a response to the combined analysis and methodology



## II. Slum Renewal and Urban Regeneration

Urban design aims to make better cities for everyone, but, due to the nature of urban economics, the benefits are often felt most by the economically advantaged sectors of the population. In some cases, urban design actively marginalises the poorest members of society, such as the homeless population.

This is not to say that urban design cannot be a powerful tool for improving the conditions of the urban poor. Urban renewal and regeneration efforts have been attempted in many cities around the world, often with partial or substantial focus on improving the conditions of the poor.

Unfortunately, these projects can backfire, and lead to gentrification, which creates conflict and further marginalisation. This can be seen, for example, in London, where the regeneration of the East End has caused backlash and resistance from the traditionally working class population (Hubbard & Lees, 2018).

## **Urban Design in Informal Settlements** Lessons in urban renewal for impoverished areas from around the world



This raises the question, then, of how urban designers can effectively and consistently serve the world's poorest urban inhabitants? How can urban design be used to upgrade slums and informal settlements, without falling into the trap of making only superficial changes or improving the root causes of slum environments?

Before proceeding, an important note on terminology: slums and informal settlements are not the same things. Both receive a more complete definition in the glossary at the end of the thesis, but for the present a broad distinction between the two can be made. An informal settlement is an urban area that is outside of government control or sanction, and therefore illegal (UN Habitat, 2003, p. 196). It is common for informal settlements to be the homes of the urban poor, but not a defining characteristic. Slums, by contrast, are defined by their poor socio-economic status, the quality of the urban environment, and the lack of services available to slum-dwellers (UN Habitat, 2003, p. 1). For the purposes of this thesis, the degree of overlap between these two terms is sufficient as to allow them to be used interchangeably when applied to a general condition (such as slums as an urban typology); more care is taken when applied to a specific situation, however, such as the Egyptian context.



From top: São Paolo, Brazil; Guatemala City, Guatemala; Hue, Vietnam

Historic methods for dealing with slums have been largely ineffective. As Teferi and Newman observe, the traditional methods comprised neglect and clearance, and often led to a new decrease of the amount of low-income housing that is available, exacerbating the problem (Teferi & Newman, 2017, p. 5). The top-down approach to slum upgrading, demonstrated through such government initiatives, is often paternalistic, and fails to address the needs of the people supposedly being helped.

In Nagpur, India, De Geest and De Nys-Ketels examined the effects of community participation in slum improvement projects (2019). After conducting a number of both informal and semi-structured interviews, they found that top-down approaches to slum upgrading, even when conducted with good intentions, can easily neglect the input from the local community. This neglect, in turn, can have repercussions for the success of the project, such as causing resistance from the local community. Examples of resistance that they encountered include both overt forms (public protests) and more subtle ones (illegally extending apartments).

In India, the sheer scale of the task and the limited resources available has caused government initiatives to upgrade slums to struggle and fail (Neekhra, 2008). For this reason, Neekhra asserts that public-sector driven

programmes are insufficient to really influence the problem, and so private sector engagement is necessary (Neekhra, 2008). While this conclusion is sound, it arguably does not go far enough, as it continues to follow a model that suggests that more resources will enable greater positive impact for slum residents.

By contrast, the efforts of Fabienne Hoelzel in São Paolo aimed to see the informal settlements and their residents as a resource rather than a problem (Hoelzel, 2013). In the case of the Serra da Cantareira, an endangered urban rainforest region within Brazil, Hoelzel and her team helped transform the informal settlements into 'startup communities', that both support economic development while also protecting the ecosystem. This kind of positive approach to informal settlements and their inhabitants is preferred in this thesis because it establishes a constructive perspective on the settlements, rather than the more obstruction- or problem-oriented perspectives of traditional slum upgrading practices.







From top: Chonqing, China; Jakarta, Indonesia; Mumbai (Dharavi), India

This is not to say, however, that government involvement is not still a valuable component in improving informal settlements. For example, recognising the difficulties of supplying basic infrastructure and utilities to poor urban communities, Amado developed a method for use in East Timor, known as Wall-Up (Amado, 2018). The concept of Wall-Up revolves around a physical structure – a "Technical Wall" – that houses the assorted infrastructure necessary for a housing unit: water, electricity and sewerage removal. By establishing this structure, the public sector is able to manage and oversee the provision of utilities, and housing can be 'plugged in' with relative ease and low cost. While this concept may not be entirely transferable due to the relatively low-density of East Timor's informal settlements, the modularity that it employs offers some interesting potentiality for affordably improving deprived urban areas.

Teferi and Newman describe two approaches or frameworks to slum upgrading, which they call the Modernist and Organic approaches (Teferi & Newman, 2017). The Modernist approach is, more or less, the traditional way projects have been conducted: demolition of in situ settlements and their replacement with new high-rise structures and affordable housing. By contrast, the Organic approach, aims to "respect the informal settlement for what it is", shifts to a "more community-based renewal of slums", with the goals of creating economic opportunities and maintaining the existing social structure.

By using these two approaches as analytical frameworks for slum upgrading activities in Addis Ababa, Ethiopia, the authors can observe the relative effectiveness of each. They acknowledge that the Modernist approach has the potential to improve the economic and environmental conditions of the area (Teferi & Newman, 2017).

However, this success is never guaranteed, and comes at the cost of the social cohesion of the neighbourhood: the same social cohesion that enabled Hoelzel's 'startup communities' to flourish in São Paolo, for example. Their study found that the Organic approach, on the other hand, provides the same benefits, while also empowering the community to continue upgrading the slum, thus giving self-sustaining momentum to the urban improvements.

In multiple cases, therefore, slum upgrading has proven to be more effective when the needs of the community are heard by the designer. Furthermore, the failures of top-down approaches go further than simply a lack of resources. They include the failure to plan for the long-term, the



Clockwise from above: Jalousie, Haiti; slum upgrading in SãoPaolo, Brazil, by Cities Alliance; Manila, Philippines; outdoor escalator in Medellín. Colombia







failure to engage the community and provide them with a sense of ownership or inclusion in the project, and a failure to recognise what is culturally and symbolically important for the intended beneficiaries.

One last example can be instructive, before drawing some concluding remarks. Architect Mangaliso Chima explains that in Malawi's slum areas, poor hygiene and lack of infrastructure is costing lives (2016). To combat this problem, he developed three concepts that have been tested in Lilongwe and proven to be effective:

- first, for new residential areas, housing is clustered around courtyards, rather than constructed in rows (using less land in the process);
- second, existing slum developments have been carefully analysed, and precise surgical interventions conducted to improve their environment - for example, composting toilets and closed sewers; and
- third, houses have been designed to allow expansion incrementally, as and when the needs and abilities of the occupants permit.

These innovations, which alone seem like minor design concepts, have nonetheless had a profound effect on the communities in which they have been implemented. The courtyards have reinforced communal values and residential safety, established symbolic and physical connections to nature and African culture, and provided natural light and ventilation. Health and hygiene have been improved in the existing settlements, while individuals in both existing and new areas have been given greater economic independence.



From top: compost toilet and shower unit in Lilongwe, Malawi; upgraded drainage system in Maputo, Mozambique; infrastructure hub in Makoko, Lagos, Nigeria

A common thread emerges from these examples: large sweeping projects that try to capture a utopian vision are rarely, if ever, successful. Instead, urban designers should seek to take advantage of the resources already present - the community and the networks - in order to enable small scale interventions at the local level. By taking this approach, not only can the physical environment be improved, but it can continue to improve progressively as the economic and social forces are made stronger, not weaker, from intervention.

Looking at these examples, then, reveals how urban design can improve slums. By using modular design, social entrepreneurship, incremental interventions, and community engagement and empowerment, long-term sustainable regeneration can be achieved.







## III. Understanding Informal Cairo

This chapter explores the nature of informality in Cairo, and serves as the analysis of the context of this design proposal.

The chapter begins by explaining the reason that Cairo has been chosen as a case study, and then provides a description of the process by which informal settlements emerge in the city. This description is followed by a more in-depth look at the physical characteristics of Cairo's informal settlements, followed by a discussion of the social, cultural and economic aspects of life in these settlements. Lastly, some concluding remarks are provided, in which the principal opportunities and constraints of the settlements are explained.

It should be noted that, since this project aims to address a problem that is present all over the city (and, indeed, globally), no specific site will be examined but rather an urban typology. The implication of this, of course, is that a degree of abstraction and generalisation is inevitable.

## Why Egypt? Why Cairo?

Egypt has one of the largest populations and economies in the Arab world and in Africa. As part of the developing world, the country is nonetheless wealthier and possesses a higher amount of institutional resilience than many others. The position of Egypt and its status economically and politically (and, perhaps, culturally and historically) give it the potential to take a leadership role amongst other countries in the region and beyond.

Cairo, the largest city in Africa, is expected to grow significantly over the next 10 years. As a city with so many people, mitigating its environmental impact, will go further towards tackling global problems than achieving the same result in a smaller city.

Due to the nature of informal settlements, it can be difficult to gain accurate data about them, for instance their population and economic activities. However, estimates in Cairo state that nearly two thirds of the population - about 11 million people - live in these kinds of settlements. These numbers emphasise the scale of the problem, and the potential that it offers.

Furthermore, the Egyptian government has announced plans for a new capital city in the desert (outside Cairo), with the stated purpose of relieving congestion in the city, and adopting environmentally sustainable practices. It is not implausible that the real purpose of the new city is a vanity project for the new Egyptian regime, however.

Cairo

Area

17,267.6 sq. km.

Population

20.90 million

Annual averages







## **Evolution of an Informal Settlement** Understanding the stages of development in the Cairene context

Several 'types' of informal settlement can be identified – on privately-owned agricultural land, on government land in the desert, and around historic village centres [Sims, 2011]. Those which occupy agricultural land are the focus of the thesis, as they are both the most numerous and the most environmentally damaging.

The settlements usually occur because developing farmland for residential purposes is more economical than retaining its use for agriculture. Colonel Nasser's land reforms in the 1950s distributed ownership of agricultural lands to the people who worked on the land, setting the context for small-holding private land ownership throughout much of Egypt. The agricultural land is divided into long orthogonal strips, with irrigation channels along the narrow side (1).

When a settlement begins to form, the farmers divide the strips into smaller parcels, which are then sold by the land-owners (2) and illegally begin to be transformed into informal settlements (3). The buyers of the land are rarely individuals, but rather a collective or group, such as extended family, a collection of neighbours, or members of a particular mosque. Often the land purchase and development is financed by Egyptians working in the Gulf States and wishing to invest their salary securely.

Due to the nature of the development, it is common for buildings to be erected incrementally: that is, as funds become available, new floors are added on top of the existing buildings (4). As construction commences, the irrigation channels are filled in and become the primary access routes for the development.

The informal settlement, therefore, takes shape from the actions of multiple land-buying individuals and groups, evolving organically over time, and without being sanctioned or supported by any level of government (5).Due to this decentralised and self-organised process, the configuration of each settlement differs, while the architectural style and materiality remains consistent across the city.

It is not uncommon, for example, for unsold agricultural plots to remain as isolated pockets among the tall residential buildings, for lanes and vacant land to be mixed into the otherwise dense urban environment, and for buildings to stand empty or partially complete while funds are accumulated (6).





## **Evolution of Informal Settlements** Examples of areas of Cairo at different stages in the development of an informal settlement

Top left: agricultural lands in privately owned orthogonal along the outer bound- filled in and are formary of the fields.

Top right: the first stages of development are strips. The irrigation land. The irrigation channels are visible channels have been ing the main streets.

of agricultural land are occurring within the still visible. The ring has emerged, and aproad was built with pears as an area of the intention of limit- dense buildings withing the growth of such out public or green settlements, but has space been ineffective.

Bottom left: pockets Bottom right: a mature informal settlement

Note that all satellite images are taken from Google Earth. As such, it is not possible to ensure the same scale in all cases. As much care as possible has been taken to match the scales, however, and all images on the previous page were taken from a camera altitute of between 1867m and 1888m.





argument is that the informal settlements of

Cairo are an effective but flawed way of housing

large numbers of people at the minimum cost.

Considering the nature of informal settlements

and slums around the world, his argument is a

strong one: residents of Cairo's settlements live

in higher quality housing than in comparable

other settlements around the world, and have

better access to basic utilities and infrastructure.

The 2008 Housing Study for Urban Egypt (HSUE)

reported that 96.7% of households in Greater Cai-

ro have direct access to potable water, and 98%

are connected to sewerage lines (Sims, 2010, pp.

258-260). Electricity and telecommunications are

similarly well supplied across the city.

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## **Cairo's Informal Settlements** Access to services and utilities

The most comprehensive and thorough resource on Cairo's informal settlements is David Sims' Understanding Cairo: The Logic of a City out of Control (2010). It should be noted that, while Sims' work is both well-researched and well-analysed, it may not be as relevant today as when it was published: notably, it does not encompass changes that may have occurred to the city's urban conditions as a result of the 2011 revolution that ousted President Hosni Mubarak (whom ruled Egypt for 30 years), nor the years of instability that followed. Despite this shortcoming, Sims' work serves as an excellent guide for Cairo's informal settlements.

Sims' provides an unmistakeably positive assessment of Cairo's informal settlements. His



80 - 150 sqm. 75 - 125 sqm/ 83% - 93% 6 (ground +5) 1 - 3 40 - 80 sqm.

SOURCE: Sims, 2010, pp. 95-103

Left: typical floorplan for an informal house (after Sims, 2010, p. 124) and informal settlement housing statistics

## **Cairo's Informal Settlements** Materiality, morphology and massing

The physical structure of buildings is also comparatively robust. Structural integrity is provided by reinforced concrete columns and floor plates, which carry the load of the building and provide a high degree of stability. Internal and external walls are then constructed from red bricks, which are freed from the need to be load-bearing. This structural typology, which is often selfbuilt without heavy machinery, provides a strong architectural form at a low economic cost. It is worth noting the intensive usage of impervious materials, which also gives the settlements a very hard and unyielding texture.

Despite the comparative strengths of Cairo's settlements, there are also numerous drawbacks. The density of construction is immense, with



Top: a partially constructed building shows the reinforced concrete structure and the red massonry walls

Above: high levels of massing are the result of dense construction and minimal open space provided



very little space afforded for public use. Due to the economic imperative of maximising the use of the space and the lack of any form of regulatory oversight, buildings occupy as much of their block as they can, leaving very narrow spaces for streets and alleys.

As the buildings grow taller - and often overhang the small amount of street space that is available - the oppressiveness increases accordingly. Sunlight and ventilation are therefore impeded in these settlements, and vehicular access is often also very limited (a particular issue in terms of emergency vehicles and waste collection).

The massing can, in extreme cases, block a unit's access to sunlight altogether, as can be seen with Unit 2 in the floorplan on the previous page. Ventilation shafts become the only way for some residents to have access to fresh air in their homes. Furthermore, the incremental nature of construction in informal settlements can result in buildings having a perpetually unfinished appearance.

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## **Cairo's Informal Settlements** Life, Society and Economics





From top: pigeon farming on the rooftops; street in Boulaq al-Dakrour; street vendors

As is commonly found in informal settlements and slums around the world, the social cohesion of Cairo's settlements is very high. This largely occurs due to the frequency of networks locating close to each other, whether that's extended family, friends, or people migrating to the city from the same part of Egypt. Additionally, as the residents cannot rely on government support, social networks become an important safety net when times are difficult.

Informal settlements are often - unsurprisingly - home to informal economies. As Sims notes, entrepreneurs are attracted to informal settlements, due to the high concentration of potential customers, but this also makes competition high. The types of business that can be found, according to Sims, are retail, workshops (eg. carpentry, metal, repair), transport, construction, personal care, and some IT activities (Sims, 2010, p. 121).

Ahmed Soliman provides a glimpse into the life of an informal settlement in Egypt (2013). He notes that the street forms the principal stage for social and economic activities, and that it is dominated by the presence of women and children. Men, he states, do not take an active role in the 'life of the street'. Additionally, he notes, that balconies play an important role in the social environment: both as a means of connecting with neighbours, and also as a source of friction (on account of the close proximity and the negative impact that has on privacy).

Soliman's perspective on the informal settlements is distinctly different to that of Sims. He observes, for example, that the settlements are felt to be "a compromising place to live" by those who live there (Soliman, 2013), and that the social cohesion that makes the place supportive, can also cause isolation or hostility to someone who is not connected to the network.

## Opportunities & Constraints in Cairo's Informal Settlements

From this analysis, Cairo's informal settlements appear to be contradictory. On one hand, they provide a higher quality residential environment than comparable settlements around the world, with services and utilities being provided and the cost kept to a minimum. However, this benefit comes at the significant cost of being over-crowded, restrictive to vehicular access, lacking in public space, and almost completely devoid of any greenery.

Similarly, the settlements demonstrate a strong social cohesion and vibrant economic activities. But residents in such settlements nonetheless possess little economic or housing security, and a sense of stress associated with living in near poverty.







The most significant constraints in this context, then, are the neglect of the Egyptian government and the lack of financial capital. Another constraint may be the herculean task of retro-fitting so much of the existing city. Speculatively, a cultural lack of interest in public green space may also be a constraint to consider.

The opportunities presented in Cairo are primarily those of human capital. The inhabitants of Cairo's settlements have demonstrated a willingness to work hard, the capacity for entrepreneurial innovation, and the desire to create and maintain a public social sphere. Additionally, the 'template' of Cairo's informal architecture (reinforced concrete and red masonry) serves as a model for low-cost but high-quality building.



## IV. Towards Green Informality

As has been demonstrated, a robust methodology is an essential component in the success of any slum upgrading project.

The following chapter begins with a description of the design strategy. The purpose of the design strategy is to provide a big-picture perspective on the key issues that are being addressed, and how they contribute towards a final design solution.

This section is then followed by the presentation of the green space framework. The green space framework is a model for understanding and designing green spaces in cities that fits within the principles of biophilic urban design. It is accompanied by a set of tools to enable designers to more easily apply the outcomes.

Lastly, a set of design principles are reached. These design principles will guide the design process and establish the key elements required for the project to be successful. As such, they are devised on the basis of all of the material presented thus far.

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## **Design Strategy** The lens, the focus, the approach

The design strategy adopted in this thesis comprises three elements: the theme, the lens, and the approach.

The theme is the central governing concept or issue in the design. It can be compared to the main priority of the design, which in this case is enhancing the presence of green and natural elements in the urban environment.

The lens can be described as a specific dimension or component of the issue, and is primarily intended to address one of the principal challenges or constraints facing the design process. Based on the previous analysis, the key lens in this thesis is the economic dimension of Cairo's non-linear process. informal settlements.

Lastly, the approach refers to the way in which the design will be implemented, and so highlights the feasibility of the solution. This is relevant to the design strategy because it can help inform the methods of the design so that they are scaled to the approach. In this thesis, the design is approached through the element of community. This aspect will receive more attention later in the thesis.

It is important to note that the design strategy is hierarchical. The theme exists above each othAs noted in the previous chapter, one of the most distinctive features of the morphology of the informal settlements in Cairo is their verticality and massing. The narrow streets are comparable to urban canyons. In the effort to make the city more natural - more biophilic - a different analogy can be a useful concept for the design; namely, the analogy of an urban forest.

A much-simplified overview of forest ecosystems divides them into layers: undegrowth, understory, canopy, emergent. Generally, the highest layers receive the largest amount of sunlight, rainfall and airflow, while the lowest layers have the least. Different organisms have adapted to thrive under the different conditions of a forests vertical layers.

er element, and the lens takes precedent over the approach. This hierarchy should not, however, be treated as a strict chain, but rather as a





## **Design Concept** From the ground up



This same concept of layers can be applied to Cairo's settlements, and for much the same reasons. The street receives the least amount of ventilation and sun (in the latter case, this is a potential advantage, due to the intensity of the Egyptian heat), while the rooftops receive the most.

The design proposal of this thesis, therefore, will look at the buildings in layers, from bottom to top. More than this, however, they need to be perceived as layers chronologically, too. Since the buildings are created incrementally, the design concept must cater to both spatial and temporal aspects of the informal settlements.

## **Green Space Framework** Affordances star and Green Space Wheel

The Green Space Framework is a conceptual approach to analysing and designing urban green space. The framework emphasises five characteristics of green spaces that are deemed to be important or valuable within the context of biophilic urbanism: connectivity, quantity, environmental quality, anthropocentric quality, and integration. Combined, these form the Green Space Wheel.

The concept of the Green Space Wheel was directly inspired by the work of Lennon, Douglas and Scott in their "affordances star," a visual heuristic that they developed to analyse green space from the perspective of health and well-being (2017).

The affordances star arranges the key characteristics being examined at different points on a star. This representation allows the user to select the characteristic of most interest - say, persons (meaning the different groups who use the space) and examine how that characteristic relates to those that are connected to it (eg actions or objects).

Alternatively, the use can choose to start with a relationship (say, objects-persons), and explore how it influences the other relationships it intersects (spaces-scales and scales-times). As an analytical tool, the advantage of the star is that it emphasises the relations between characteristics. rather than the characteristics in isolation.

The Green Space Wheel takes this same concept, but rather than the relationship between each characteristic being represented on a line, it is represented via overlapping shapes. This simple visual modification highlights the varying degrees of inter-connectedness of the five key characteristics, and also points towards a hypothetical 'centre space' where all five characteristics meet.





Top: 'affordances star' concept from Lennon, Douglas & Scott (2017) that served as inspiration for the Green Space Wheel

Above: the five characteristics of good urban green space for the Green Space Wheel, in which each characteristic is connected to the others to a greater or lesser degree

## **Green Space Framework** Qualities of good urban green space



The extent to which urban green patches are connected together in a network. Well connected green patches enable easy human access, support habitats and biodiversity, and create corridors of natural land within a city.



The amount of green space in a city, as a proportion of the overall urban area. Larger quantities of green space in a city support more natural affordances, which provide benefits to both the natural environment, and the urban residents.



Good anth. quality

Good integration

Not all green spaces are equally effective at delivering environmental services (eg. supporting biodiversity, removing pollutant particles, mitigating UHI). This characteristic considers how well the patch is able to provide these services.

## Quality (anthropocentric)

The extent to which the green patch accommodates human users. This can encompass the range of facilities available (eg barbeques, playgrounds, outdoor gyms), and the level of access and safety (eg ramps, lighting, parking, free entry).

#### Integration

Green spaces are more effective in a city if they are treated as part of the city, rather than as distinct from it. This characteristic describes the extent to which green spaces are integrated into the urban fabric, and even the extent to which they are incorporated into buildings.

## Connectivity



## Quantity

## Quality (environmental)



Poor quantity





## **Green Space Analysis Framework** Green space toolbox

The green space framework is intended to be used in combination with a toolbox of common design practices and concepts. The framework itself establishes the desired outcomes of high quality green spaces within a city, and the toolbox assists the designer in reaching those outcomes.

The five tools are: grain, scale, density, mix, and height. Each of these tools is based on common existing urban design concepts, but is redefined within a strictly green spatial context. Urban grain, for example, describes the texture of built and unbuilt spaces within a city; within the green space toolbox, however, grain describes the texture of green and non-green spaces.

The use of these tools is based on normative assessments, informed by the qualities of good green spaces described on the previous page. Thus, a fine grain among urban green spaces helps to establish a high level of connectivity; larger scale green patches increase the quantity, while smaller scale green patches can potentially also support greater connectivity.

There is no right or wrong way to use these tools, as every instance must be treated within its own context. Furthermore, the particular norms desired will vary depending on the scale of the intervention: the average density of green patches at a metropolitan scale will differ when viewed from a local or neighbourhood scale.

As a general rule, it is preferable to develop a green space network that is multi-scalar. That is, attention should be paid to the quality of individual green patches, just as much as it should be given to the entire matrix of green spaces in - and beyond - the urban landscape.





The types of green space can be broadly divided into four categories based on their expected service or use:

- recreational and leisure: to be enjoyed as urban parks or sports and play areas;
- economic: providing or accommodating an economic service to the community;
- communal: supporting the social networks

Pa

## **Types of Green Space**

of an area or group; and

• passive: providing additional benefits and services to the wider urban context.

It is essential to note that these services and types are not mutually exclusive: a single green patch may (and, indeed, should) offer some or all of these services simultaneously.

# **Precedents & Inspiration I**

I. Nature

I. Nature

1. beehive 2. seaweed (microscopic) 3. leaf (microscopic) 4. wood (microscopic) 5. termite mound 6. animal trails in a swamp





Design does not take place in a vacuum. Inspiration is taken from both natural and artificial sources. Given the strong emphasis that this thesis places on biophilic design, the natural world has been an important source of inspiration.

This thesis has employed a central philosophy throughout, which is that nature offers lessons and value that urban designers can apply to cities to benefit residents.

For example, the images on the opposite page demonstrate the patterns of natural construction, whether it is bees creating a hive or the cellular structure of wood. These patterns have survived the test of time, and are therefore demonstrably resilient in the face of changing global circumstances.

Patterns of animal movement are also of interest. Animals generally aim to behave in a way that is efficient and conserves energy, as this enhances survival. The trails that animals leave, therefore, may offer ideas for human movement patterns.

# **Precedents & Inspiration**



# **Precedents & Inspiration**

II. Architecture

II. Architecture

7. The Farmhouse, Precht

In addition to natural sources of inspiration, the work of other designers also serves as valuable precedents for the design process.

Several of the images on the opposite page display green space as a productive component of leftover and marginal spaces (such as the rooftop of Precht's conceptual Farmhouse, or occupying an otherwise vacant wall in the GreenBelly design).

Another important criteria in the selection of these precedents is the integration of nature and architecture, which serves as a demonstration of the potential for biophilic urbanism. This is best displayed in Boeri's Bosco Verticale, the Farmhouse, and London's Tower Farm (which also serves as an excellent example of the potential for highdensity vertical farming).

Lastly, attention is drawn to patterns of historic and traditional urban and architectural form in Egypt and the Arab world. These patterns are the product of centuries of adaptation to the local climate.



# **Precedents & Inspiration**

## **Principles of Design for Informal Settlements**

The design principles bring together the various ideas and information that has so far been discussed, and condenses it into the key elements that must be considered in the design and implementation of this thesis.

Each of the elements described below is significant in the context of this project for one reason

or another. However, it is important to note that they do not exist in isolation from each other.

Rather, they should be treated as part of a matrix of interconnected elements. The diagram on the opposite page shows some of the most important connections between the elements.





The diagram above shows the main relationships between the design principles of this thesis. By arranging the design principles in this way, no single one of them is placed higher than any other. This is a deliberate choice, as the final design and implementation strategy must be capable of demonstrating, at least to some extent, all of these design principles.



## V. Presentation of Spatial Interventions

This chapter presents this thesis' proposed solution to the problem of Cairo's lack of green in informal settlements. Before proceeding, two points should be noted.

First, the chapter is structured in two parts. The first, and much longer part, follows the process of creation of a building in an informal settlement, from the stage of the initial land parcels, through to the 'completed' building. The second part describes some of the ways that green elements can be included in the architecture, and their advantages and disadvantages.

Second, this design is not a polished final product, but rather a template that can - and should - be modifed and adapted as necessary. This has been mentioned previously, but it is worth reiterating: in order to be effective, the design solution must be adaptive to local and temporal conditions, and should be responsive to the needs and capacities of the communities involved.

## Stage I Land parcels and land sales

It is necessary to accept that the agricultural land of Cairo is going to be developed. This is the only realistic conclusion that can be reached, based on the realities of Cairo's demographics, economy, and government.

The small size of the agricultural plots makes them unprofitable for farming, but highly desirable for development; at the same time, government actions (and inactions) make it difficult for farmers to compete, and easy for them to subdivide and sell the land.

The land sales occur because the farmers are unable to maintain a profit by working it. The first stage of this proposal, then, is that the farmers maintain a stake in the land. This will occur by them selling the land on the agreement that they retain exclusive right to sell any surplus produce that can be grown form the green spaces on and around the buildings. The residents become the primary producers, and the farmer serves as a middleman, who - possessing experience in agricultural practices - is incentivised to maximise agricultural output.

In the existing process, each purchaser of the land acts as an independent entity, with little or no collaboration with neighbours. The only apparent concession is in terms of the shared access route that multiple properties use.





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## **Stage II** Beginning construction

In this proposal, developers will be encouraged to collaborate with each other, and form loose cooperatives. This encouragement takes the form of shared communal spaces (eg central stairwells), thus saving each of them a share of the cost of those spaces.

In exchange, the developers adopt a structural form that is based on a modular design. The design involves the same structural components as are currently used (load-bearing reinforced concrete, and masonry infill walls), but the masonry components are not added unless specifically required. This allows spaces to sit vacant – and be used for green elements – until there is a demand or need for a different purpose. At that point, a new infill form can be added.

The first stage in this process is the creation of the ground floor supporting structure.



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## **Stage III** Ground level infill

Once the initial structural supports are erected, masonry walls can begin to fill the remaining spaces. The design specifically leaves a vacant space in the middle, which can serve as commercial, cultural or social space, while also providing access to the higher floors.

The ground floor portions of each building are expected to focus more strongly on non-residential uses, and may also include administrative facilities for the developers/co-operative.

Another function of the ground floor is as the commercial premises of the former farmer, in which agricultural produce can be sold. This not only encourages food production by the residents of the building (as mentioned earlier), but also gives a commercial nucleus around which economic activity can be built.



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## **Stage IV** Going up

As the building grows higher, the structural concept begins to take shape. A central atrium provides ligh and ventilation through the entire building, while the as-yet-unused roof spaces are converted into green elements. The atrium can also serve as a home to green elements, such as hanging plant baskets (see types of green elements, on pp. 66-67).

These elements serve as more than simply a single type of green space. For example, a set of agricultural plots will provide aesthetic and recreational functions, while also generating compost and fertiliser (potentially marketable products).

One of the key characteristics of this design proposal is that, as the building emerges, green space is treated as the default use of any non-occupied areas. This ensures that the green elements have a prominent role, as well as helping to support the green economic activities.



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## **Stage V** First floor infill (1)

As resources become more available, vacant spaces can be filled in with masonry, and used for a variety of purposes. In most cases, it is expected that they will be used as residential units, but the option will exist to allow them to also be adapted to commercial or industrial activities.

The design of the building - with supporting pillars acting as a kind of grid-like matrix - creates natural areas that will be filled in by the community. Each developer in the cooperative will manage the construction of is or her own property, but with a shared interest in maintaining the central atrium.



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## **Stage VI** First floor infill (2)

As the settlement matures, the density will increase. Undoubtedly, given what has already been discussed about the economic priorities for high density, the principal motivation of the developer will be to create the highest density possible, which will likely come at the expense of the green spaces.

Two aspects of this design serve to discourage this from happening. First, by being part of a cooperative with other developers, the individual developer will be limited in his or her ability to interfere with shared spaces.

Second, by explicitly growing the green elements alongside the economic elements, the viability of greenery is expected to be greater, thus increasing the incentive to retain it.



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## **Stage VII** Going up again

As each floor is infilled, the developers will begin rising higher in their construction. And thus the pattern begins again. Through the measures described previously, however, spaces will be left open to enable air and greenery to remain a presence in the structure, even as it rises to much higher levels.



## Completion

Given the adaptive and evolving nature of this dents are afforded both on a much higher scale than is presently visible in Cairo's informal settledesign template, these structures are never expected to be 'complete'. However, one can presume that, eventually, they will rise to their maximum height.

Due to the nature of this design, open space and green space are integrated together, and resi- tive area on the ground floor, framed by green.

ments.

The central atrium will serve as a visual and physical access way, that unifies the entire design, and culminates in a socially and commercial ac-







## **Green Elements** Examples of the forms of green element that can be incorporated into construction

This thesis has discussed many contexts in which tive green elements. Alternatively, some types green may be included and encouraged in Cairo's informal settlements. On this page, some of the specifics of the types of green element will be examined.

These elements have been divided into six 'types': windows, pergolas and trellises, rooftops, hanging gardens, walls (vertical gardens), and balconies and landings.

Each type offersparticular advantages and disadvantages, and so variety is preferred, and a balance between different types. For example, using green elements that occupy a smaller floorspace can increase the areas available for infill, but also requires more complex or less interac-

it's own scale of window planting.

engage a more decentralised and individualistic approach to green elements - i.e. it is the prerogative of householders and residents - while others possess a more public or accessible quality.

In all types, however, multiple functions are possible. Even the smallest type of green element a window plant or a suspended basket - can be used to grow herbs or vegetables, or produce fertiliser that can be used elsewhere.

Furthermore, any presence of green in a space will have beneficial effects on visitors and residents alike, through air purification and reducing stress and anxiety.



This type of green element can also be an effective way of creating or partitioning outdoor open spaces, with varying levels of privacy or access permitted.



This makes them very versatile, and enables them to offer multiple functions, such as recreational parks and urban agriculture.

Walls



Including green elements on vertical surfaces and walls can provide the largest quantity of additional green surface, without reducing the available floorspace.

The major disadvantages of vertical gardens are that they are technically more complicated and expensive to install and maintain, and they have comparatively little opportunity for direct interaction.

## **Green Elements** (cont'd)

## Hanging Gardens



Greenery can be suspended in baskets or containers, which is both low-cost and low maintenance, and has the enormous advantage that it does not occupy any of the valuable floorspace.

The disadvantage of this type of green is that it does not offer a large amount of space or interaction, and so provides fewer uses to the residents.





Private balconies are another area where residents can express their personal preferences for greenery. As noted previously, the close proximity of balconies can have negative impacts on privacy, and the inclusion of green elements can reduce this effect.

Additionally, communal areas, such as staircase landings, central atriums and corridors can include green elements, to increase saturation of green.



## VI. Testing the Design

A key goal of this thesis is not only about proposing a design solution, but also devising a way of implementing the design to ensure that it can be as successful as possible.

For this reason, four aspects of the design need to be explored in more detail: how to enable greenery to survive; how to ensure the residents will choose to prioritise greenery; how to ensure the design can adapt to changing circumstances; and how to ensure the design can actually be implemented.

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## Making it Green Using (and reusing) water

One of the key challenges that this design faces lies in the provision of water to sustain the greenery being introduced to the city. As has previously been noted, many Cairene households are equipped with running water and sewerage systems, but it may not be realistic to expect that those systems will be extended to greenery, especially in a country with such a dry climate and scarce natural water resources.

The solution that is proposed in this thesis is that the plants are kept watered with the use of waste water from households and non-harmful commercial and industrial activities. Since the water is being used on food and agricultural products, it is necessary that it is safe and hygienic for consumption. Thus, some forms of waste



Waste water is separated into reusable and sewerage at the household/business level. Sewerage goes directly into the city sewer system

Reusable water is channeled into a cistern, where it is supplemented with fresh water. The cistern is shared by multiple buildings for common use

Water is pumped to green patches, and channeled from one green patch to the next. The further along the process, the cleaner and safer the water becomes

water would need to be disposed of directly (eg solid waste from toilets, anything that contains household or industrial chemicals).

Furthermore, one of the specific goals of the green space design would be to help purify the water that is being used; plants are effective at absorbing minerals from water, and the correct selection of plants can help to clean the water before it reaches food crops. Papyrus - which has many economic uses and also has a long cultural association with Egypt - is an excellent example of such a plant (Mburu et al., 2015).

To achieve this, waste water (of acceptable useability) will be collected by a complex of buildings in a ground-floor cistern, and can then be distributed across the structure and neighbourhood via the use of low-cost and easily installed solar pumps.

To reduce issues of smell and sanitation, the water will need to be supplemented with fresh water. The demands of this system on fresh water, however, will be smaller due to the combined systems.

An additional feature of this system is that the waste water will get progressively cleaner as it goes through the green patches. Due to this, and to avoid issues of smell and sanitation, the first plant users of water should be kept further from human activity or capable of being relatively self-contained; for example, bioenergy production.

Equally, food plants and consumables should be the last to receive the water in the system, as it will have gone through sufficient purification as to be safe for consumption.

Building a green economy

The absence of natural elements in Cairo's informal settlements is indicative of the low priority that it receives in the mind of inhabitants. Considering the economic situation for many residents of such settlements, this apathy is understandable. However, a key priority of this thesis is to change the culture, so that spaces that contain plants are perceived as **more** desirable than spaces that exclude them.

Cairo's informal settlements are deeply capitalistic - maximum income generation per metre squared, at minimum capital and ongoing cost. Consequently, the concept of a green economy is promoted. By designing green spaces so that plants and nature are a source of income - in addition to their health and ecological benefits their inclusion becomes a matter of profit.

Urban agriculture, for example, can save money in a household's grocery shopping, or supplement income through the sale of produce. Cash crops, in particular, can be produced for additional income, though it should be noted that biodiverse green spaces are more productive than monocultures.

Other economic opportunities include carbon trading (that is, being paid by corporations around the world to offset carbon emissions through vegetation), production of energy (photobioreactors use light, water and plants/ algae to produce biomass, that can be used as a sustainable biofuel), cultivation of products for other purposes (for instance, ingredients for pharmaceuticals, or raw materials for craftwork activities like basket weaving and textiles).

These ventures, moreover, can be partially financed through microlending transactions, which have a proven record of supporting sustainable and effective entrepreneurship.

# Making it Viable







From top: diagram of microfinancing process; agricultural plots in urban farming; algae tanks for biofuel production; papyrus production



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## **Making it Resilient** Strength through adaptability

## **Making it Happen** Implementation through community

The design proposal contained in this thesis is, by necessity, non-prescriptive. In urban design there is rarely, if ever, a one-size-fits-all solution to an issue. The specifics of a location, a community, a time, and a culture, can have an enormous effect on the success of the project.

To ensure that the design in this thesis is successful, it is essential that it is capable of changing as the needs of the community change. This is also one of the principal methods by which resilience can be provided to Cairo's informal communities.

As Rauws and de Roo explain within the Dutch context, adaptability in urban design occurs where the conditions of development permit adaptation, and where the design professionals



#### Adaptability is resilience

space is used for a particular purpose
circumstances or environment changes
space changes use/function to new circumstances

4. space does not adapt to new circumstances 5. failure to adapt = fire and brimstone



are able to tweak those conditions to arrive at desired results (Rauws & de Roo, 2016). The conditions that they specifically identify are: non-linear trajectories (that is, allowing variation both spatially and temporally), responsive to the environment (avoiding specialisation can promote flexibility), and self-organising.

The settlements discussed in this project exhibit several of these characteristics already (such as self-organising), but the design proposal aims to encourage them further. For example, spaces are defined by their relationship and not their use, enabling the activities that they host to change as befits the circumstances. The title of this thesis - "From the ground up" - is not just intended to convey the vertical nature of the architectural forms, but also the implementation process itself. As has previously been shown, any project that aims to improve the conditions of low-income urban neighbourhoods whether they are slums or informal settlements - is unlikely to succeed without the direct involvement of the people who are going to be most impacted.

This approach has already been tacitly incorporated into the design strategies; the promotion of the green economy, for example, and the consideration for cost and adaptability, are intended to allow decision-making to remain in the hands of the land-owners and the residents.



Top: community garden in Lembang Rano, Indonesia

Above: community participation in slum upgrading, Yogyakarta, Indonesia



The community is particularly important in the maintenance of such settlements. A hallmark of low-income neighbourhoods is the social cohesion, but as has been noted before, this comes at a cost (see page 32). One of the goals in this project is to establish a greater role for public social interaction, which, it is expected, will reduce the feelings of isolation and the resulting hostility that it can produce.

Furthermore, this design proposal relies on collaboration between stakeholders. A central theme is that of the commons; for example, land-owners are expected to unite their properties for mutual benefit, and water recycling is shared across multiple property divisions.

(The author acknowledges the irony of a thesis in which community participation is advocated, while not employing any community engagement in the design process. The only defence offered is that it was impractical to include any form of participaton given the constraints of this project - a useful lesson of the obstacles of participatory urban design in itself)

## VII. Conclusions & Reflections

The image opposite shows the vision presented by Italian architects Stefano Boeri Architetti for a green new Cairo. While undoubtedly attractive and ambitous, this also fails to address a key issue in the Cairene context: for most of Cairo's citizens, economic pragmatism is a significant priority, and structures like this are priced beyond the realities of most residents.

This thesis has blended the ideology of biophilic urban design (as represented in this image) with the realistic potentials and expectations of the majority of Cairo's citizens. Due to the scope of this thesis, retrofitting existing settlements was not feasible.

The design that is proposed in this thesis is deliberately ambiguous. It is intended to allow variations; allow some elements to be modified or discarded, and to adapt to the changing situations within the settlements. In order to effectively address a problem on the scale described here, it is necessary to engage the community, and empower them as the primary change-makers within the urban context.

The design of Stefano Boeri's vertical forest, while wonderful in essence, is ineffective because it does not engage the community. The approach presented in this thesis aims to not only introduce green into the poorer neighbourhoods of Cairo, but also to present a model in which the residents of those neighbourhoods will welcome and embrace that green. This is accomplished by recognising the economic limitations, and presenting a solution in which a greener Cairo is also the best economic outcome.

Lastly, and in the wake of the coronavirus pandemic, it is worth reflecting on the importance of creating healthy cities. This is especially relevant in places that face government neglect and dense living conditions.



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## Appendices

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## **Design Concepts**

In the preparation of this thesis, many design concepts were developed. While most were ultimately discarded, all of them contributed to the final design proposal.

These pages show some of the design concepts produced in this process.













Left (top and bottom) units

Above First design concept: mod- Second design concept: ular units that can fit in a modular units that can be multitude of ways, and stacked vertically and horiwhich include a green wall zontally in a 3-dimensional and a green roof for every reinforced concrete matrix



Above (left and right)

Third design concept: introducing the concept of paths in the sky. The buildings are pierced by numerous openings and pathways, so that movement transforms from only horizontal to both horizontal and vertical



An extension of the paths in the sky. The left hand tower indicates the existing situation (movement only possible on the ground level and uni-directional), while the right hand tower shows the possibilities for more dynamic movement within the structure.



## **Design Concepts** (cont'd)

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## **Design Concepts** (cont'd)



ROAD ACCESS SHALED SHALED

#### Above (left and right)

Fourth design concept: returning to modular structures, experimenting with substituting units with green space. The image on the left shows the default structure; the image on the right shows the result when units are swapped out for green elements, making pathways, public spaces and bridges

Opposite page Sixth design concept. The precursor to the final design presented in this thesis.

#### Right

Fifth design concept. Introducing the idea of developers collaborating with each other to share common space, and thus reduce costs. The image on the right shows a ground floor (lower left) and then 4 variations for upper floors that can be mixed and matched as desired. The central atrium also appears in this design concept



- 1. The land parcels are typically between 80-150 sqm (Sims, 2010), which may be averaged as approximately 12 x 14 m.
- 2. The central access is typically 4-5m wide. The private portions of each building are approximately 80-90% of the floor area.
- 3. This design proposes that, rather than each parcel being developed in isolation from its neighbours, blocks of four are formed, so that each land-owner can develop his or her property with a shared vertical access.



## **Design Concepts** (cont'd)

4. Access road remains the key artery, and a small open space is included for social, economic and cultural activities.

5. A central atrium forms the access core, while the ground-level road is permitted to be bridged. The atrium includes a central shaft to help with circulation and sunlight.

6. The built form is perforated with corridors, small 'courtyards' and void spaces, to allow ventilation, access, space, sunlight, and to provide space for greenery to be integrated into the architecture.

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